PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 : E21B 17/042; F16L 15/00 — A1

(11) International Publication Number: WO 84/ 04352

(43) International Publication Date: 8 November 1984 (08.11.84)

(21) International Application Number: PCT/US84/00520

(22) International Filing Date: 9 April 1984 (09.04.84)

(31) Priority Application Numbers: 488,633; 488,778

(32) Priority Dates: 26 April 1983 (26.04.83); 26 April 1983 (26.04.83)

(33) Priority Country: US

(71) Applicant: HYDRIL COMPANY [US/US]: 714 West Olympic Boulevard, Los Angeles, CA 90015 (US).

(72) Inventor: LANDRIAULT, L., Steven ; 15809 Lakeview, Houston, TX 77040 (US).

(74) Agent: CHRYSTAL, John, J.; Ladas & Parry, 104 S. Michigan Avenue, Chicago, IL 60603 (US).

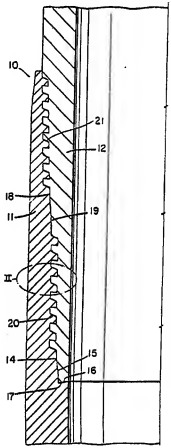
(81) Designated States: AT (European patent), BE (European patent), BR, CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent).

Published
With international search report.

(54) Title: TUBULAR CONNECTION WITH CYLINDRICAL AND TAPERED STEPPED THREADS

(57) Abstract

A tubular joint or connector of box and pin members having two-step tapered threads (20, 21). Two metal-to-metal seals of complementary engaging sealing surfaces (14, 15, 18, 19) are provided, one adjacent the end of the pin member, the other axially disposed between the two steps. Reverse angle torque shoulders (16, 17) at the end of the pin member and the interior termination of the box member and hooked threads further characterize the joint and box and pin members.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	KR	Republic of Corea
AU	Australia	LI	Liechtenstein
BE	Belgium	LK	Sri Lanka
BG	Bulgaria	LU	Luxembourg
BR	Brazil	MC	Monaco
CF	Central African Republic	MG	Madagascar
CG	Congo	MR	Mauritania
CH	Switzerland	MW	Malawi
CM	Cameroon	NL	Netherlands
DE	Germany, Federal Republic of	NO	Norway
DK	Denmark	RO	Romania
FI	Finland	SD	Sudan
FR	France	SE	Sweden
GA	Gabon	SN	Senegal
GB	United Kingdom	SU	Soviet Union
HU	Hungary	TD	Chad
JP	Japan	TG	Togo
KP	Democratic People's Republic of Korea	US	United States of America

TUBULAR CONNECTION WITH CYLINDRICAL AND TAPERED STEPPED THREADS

The invention relates generally to a tubular connection for tubular members used in the oilfield. Specifically, the invention relates to a connection for tubular members fabricated of high strength relatively thin wall material or of relatively heavy wall material as used under conditions of high tension and high pressure that are encountered in production tubing or casing employed in deep severe service oil or gas wells.

Downhole conditions in wells reaching depths over fifteen thousand feet include pressures from fifteen thousand (15,000) to twenty-five thousand (25,000) psi and temperatures approaching five hundred (500) degrees fahrenheit. Downhole conditions are often characterized as severe when sweet gas C_02 or sour gas H_2S is encountered. In order to withstand deep well and severe service conditions, production tubing and casing connectors are often fabricated from relatively thin walled high alloy steel that is not upset or cold formed. Such steel has very high strength and thus is not required to be as thick as low strength steels. Even where severe service conditions are not expected, there are instances where near maximum of tensile strength of the connection is required of non-upset or non-cold formed tubular members of relatively thin material.

Prior art connection designs provided on ends of tubular members of relatively thin material not having upsets or not processed by cold forming have been provided on a single thread geometry having a positive load flank thread. Such prior art design

leads to radial crest to root thread interference causing significant assembly stresses and jumpout failures.

Straight or cylindrical two step thread designs are known in the prior art for such members of relatively thin material, but maximum tensile strength ratings of such designs may not be achievable especially where service of the tubing members is expected in extremely deep wells.

Alternatively, under conditions of high tension and high pressure which demand that heavy wall casing be used as production casing or tie-back casing in deep severe service oil or gas wells, the production casing is often required to be three times as thick as standard API walls for comparable outside diameter pipe sizes.

Inherent with the increased wall thickness required for deep severe service wells is increased string weight and rigidity of the tubular members. Prior art thick walled connections have had a tendency for thread jump-out and seal galling. These disadvantages of prior art connections for thick walled tubular members are attributable to positive flank thread profiles of the long tubular strings and the rigidity of the thick walled casings.

Thus, there has developed a need in the tubular connection industry for a connection design applicable for tubular members of relatively thin walled material or of increased wall thickness adapted for service under deep and/or severe conditions or other conditions.

The present invention therefore provides a tubular connection of pin and box members defining an axis, said connection comprises first and second pairs of interengaged threads on the respective members, the

first pair of threads being axially spaced from the second pair of threads, at least one of said pair of threads being provided on a taper angle with respect to the axis, the first pair of threads being stepped with respect to the second pair of threads, a first pair of engaged sealing surfaces on the pin and box members disposed adjacent the end of the pin member, a second pair of engaged sealing surfaces on the pin and box members disposed axially between the first and second pairs of threads, and engaged reverse angle torque shoulders, the torque shoulder on the pin member disposed on the end of the pin member, the torque shoulder on the box member disposed on the interior end of the box member, and wherein said threads are hooked threads having negative angle load flanks.

The thin walled tubular connection of this invention is improved in that it exhibits reduced susceptibility of the connection to stress corrosion cracking in a severe service environment.

A thick walled tubular connection as modified in accordance with this invention provides a connection which allows for adjustment to tolerance variations in outside diameter and inside diameter of the pipe body without weakening the connection.

Further, the thin walled or thick walled connection of the invention inhibits excessive compression forces from radially collapsing the end of the pin member. More specifically this connection preferably creates axial compression of the internal surface of the pin thereby reducing the susceptibility of the connection to stress corrosion cracking in a severe service environment.

A further feature of the invention is that the connection provides sealing surfaces which increase the seal radial load distribution over that provided by

prior art connections thereby reducing the tendency for galling by reducing peak seal load.

Another advantage of the invention is that it provides a connection which combats the tendency for jump-out by locking the pin and box together thereby reducing collapse of the pin and expansion of the box.

Further features and advantages of the invention will be described below with reference to the following description of preferred embodiments of the invention, taken in conjunction with the accompanying drawings of which:

Figure 1 is a cross-section through a first embodiment of a tubular connection made in accordance with the invention showing pin and box members interengaged;

Figure 2 is an enlarged illustration of a threaded portion of the connection of Figure 1 illustrating hooked threads; and

Figure 3 is an illustration of the coupling of Figure 1 connecting pin members of two tubular members.

Figure 4 is a cross-section through a second embodiment of a tubular connection made in accordance with the invention showing pin and box members interengaged;

Figure 5 is an enlarged illustration of a threaded portion of the connection of Figure 4 illustrating hooked threads; and

Figure 6 is an illustration of the coupling of Figure 4 connecting pin members of two tubular members.

Figure 1 illustrates a first embodiment of the invention in which a relatively thin-walled tubular connection 10 includes a pin member 12 threadedly interengaged with a box member 11. The pin member 12 and box member 11 have first and second threaded sur-

faces 21 and 20. The first threaded surface 21 is axially spaced from the second threaded surface 20. The first threaded surface 21 is provided on a taper angle with respect to the axis of the connection of the tubular members. The second threaded surface 20 is provided on a straight or cylindrical profile with respect to the axis of the connection of the tubular members. The first threaded surface 21 is radially stepped with respect to the second threaded surface 20.

The tapered threads on surface 21 allow the threaded connection to run out to the tubular member outside diameter, thereby achieving a higher tensile rating than could be obtained if threaded surface 21 were a cylindrical thread separated by a step between cylindrical threaded surface 20.

Metal-to-metal frustro-conical sealing surfaces 18 and 19 are provided axially between first and second threaded surfaces 21 and 20. Metal-to-metal frustro-conical sealing surfaces 14 and 15 are provided adjacent the end of the pin and the interior end of the box. Complementary reverse angle torque shoulders 16 and 17 are provided on the end of the pin 12 and on the interior end of the box 11.

According to the invention, the threaded surfaces 21 and 20 are preferably provided in the form of hooked threads. An exemplary thread is illustrated in Figure 2 by reference number 40 showing that the load flank 41 is provided at a negative angle (-θ) with respect to a radial plane through the thread.

The threaded connection including the two-step profile, facilitates deep stabbing and ease of make-up between the pin member 12 and the box member 11. The hooked threads of cylindrical threaded surfaces 20 are relatively less susceptible to thread hang-up on threads of tapered bylindrical threaded sur-

faces 21 because of the tapering of threaded surfaces 21. That is, upon disengagement of the pin 12 from the box 11, the threaded pin of surface 20 is relatively less likely to hang up on the box threaded surface 21 because of the increasing inside diameter of the box threads of the tapered surface 21.

Providing the taper angle of threaded surface 21 in combination with the cylindrical stepped threads of threaded surfaces 20 enables the entire connection to have maximum thread and critical section areas allowing uniform reduction in section flexibility around the sealing regions and reduction of the relative step height between the stepped thread regions. The taper of the threads of threaded surface 21 also allows for adjustment to tolerance variations in pipe outside diameter and inside diameter provided by tubular fabricators without weakening the connection.

The torque shoulders 16 and 17 are completely internal to the connection and create an essentially recess free bore to enhance fluid flow. The torque shoulders serve as a positive stop and locking means as the pin and box members are assembled under torquing conditions. The reverse angle of the torque shoulder also serves to inhibit excessive hoop compressive forces from collapsing the end of the pin 12. The reverse shoulder angle also fixes the relation between the end of the pin and the interior end of the box. The internal torque shoulder also creates axial compression along an axial region of the internal surface of the pin thereby reducing the susceptibility of the connection to stress corrosion cracking in a severe service environment. The compressive force resulting from the reverse angle torque shoulder also tends to cause the seal region defined by sealing surfaces 14 and 15 to expand radially due to the end load.

The metal-to-metal seals defined by sealing surfaces 14 and 15 and 18 and 19 are provided respectively

as an internal seal and as a backup seal for internal pressure and a primary external seal. The sealing angles of sealing surfaces 14 and 15 and 18 and 19 are more shallow than typical cylindrical two-step metal-to-metal seals. The shallowness of the angles of the sealing surfaces increases the sealing surface contact area thereby increasing the seal radial load distribution and reducing the tendency for galling by reducing the peak sealing load.

The first and second pairs of conical sealing surfaces are preferably provided at steeper angles than the taper angle of the first pair of threads. Although the precise angles of the sealing surfaces and taper angle of the first pair of threads are dependent on the wall thickness of the tubular members to be connected, the first and second pair of conical sealing surfaces are preferably provided at an angle of approximately four to fourteen degrees with respect to the axis of the joint while the taper angle of the first pair of threads is preferably provided approximately two to eight degrees with respect to the axis of the joint.

The hooked threads provided in the tubular connection 10 inhibit the tendency for thread jump-out. The negative angle load flank threads, when subjected to tension between the pin 12 and the box 11, develop a hoop compression component. This hoop compression locks the pin and box together thereby reducing collapse of the pin and expansion of the box. A similar reaction occurs when the tubular connection is subjected to bending wherein on the tension side of the connection, the hooked threads develop a hoop compression component locking that side of the pin and box together, while the torque shoulder absorbs the load on the compression side of the bending connection.

Figure 3 illustrates a connector serving to connect the ends of two tubular members together. Two box threaded surfaces 11 and 11' serve to interengage

with pin threaded surfaces 10 and 11 of the two tubular members. The connection between box 11' and pin 10' is the mirror image of that between box 11 and pin 10.

Figure 4 illustrates a second preferred embodiment of the invention wherein a thick walled tubular connection 110 is disclosed in which a pin member 112 is threadedly interengaged with a box member 111. The pin member 112 and box member 111 have first and second threaded surfaces 121 and 120 which are preferably provided on identical taper angles with respect to the axis of the joint. Under certain conditions, the taper angles of the first and second threaded surfaces may be provided on different taper angles. Extension lines 130 and 131 are shown extending along the roots respectively of the threaded surfaces 121 and 120 of pin member 112. The taper angles measured with respect to the axis of lines 130 and 131 are substantially identical in that lines 130 and 131 are parallel but offset by a distance S perpendicular to the two taper extension lines 130 and 131. The magnitude of distance S depends on the wall thickness of the tubular member and the length of sealing surfaces 118 and 119.

Metal-to-metal frustro-conical sealing surfaces 118 and 119 are provided axially between first and second threaded surfaces 121 and 120. Metal-to-metal sealing surfaces 114 and 115 are provided adjacent the end of the pin and the interior end of the box. Complementary reverse angle torque shoulders 116 and 117 are provided on the end of the pin 112 and on the interior end of the box 11.

The threaded surfaces are preferably provided in the form of hooked threads. An exemplary thread is illustrated in Figure 5 by reference number 140 showing that the load flank 141 is provided at a negative angle(θ') with respect to a radial plane through the thread.

The threaded connection including the two-step profile, facilitates deep stabbing and ease of make-up between the pin member 112 and the box member 111. Providing the taper angles as illustrated by taper lines 130 and 131 enables the connection to have maximum thread and critical section areas allowing uniform reduction in section flexibility around the sealing regions, and reduction of the relative step height S between the stepped thread regions. The taper of the threads also allows for adjustment to tolerance variations in pipe outside diameter and inside diameter provided by tubular fabricators without weakening the connection.

The torque shoulders 116 and 117 are completely internal to the connection and create an essentially recess free bore to enhance fluid flow. The torque shoulders serve as a positive stop and locking means as the pin and box members are assembled under torquing conditions. The reverse angle of the torque shoulder serves to inhibit excessive hoop compressive forces from collapsing the end of the pin 112. The reverse shoulder angle also fixes the relation between the end of the pin and the interior end of the box. The internal torque shoulder also creates axial compression along an axial region of the internal surface of the pin thereby reducing the susceptibility of the connection to stress corrosion cracking in a severe service environment. The compressive force resulting from the reverse angle torque shoulder also tends to cause the seal region defined by sealing surfaces 114 and 115 to expand radially due to the end load.

The metal-to-metal seals defined by sealing surfaces 114 and 115 and 118 and 119 are provided respectively as an internal seal and as a backup seal for internal pressure and a primary external seal. Due

to the increased rigidity of the thick tubular walls, the threaded surfaces are provided on tapers thereby allowing the sealing angles to be more shallow than typical cylindrical two-step metal-to-metal seals. The shallowness of the angles of the sealing surfaces increases the sealing surface contact area thereby increasing the seal radial load distribution and reducing the tendency for galling by reducing the peak sealing load.

The first and second pairs of conical sealing surfaces are preferably provided at steeper angles than the taper angle. Although the precise angles of the sealing surfaces and taper angles are dependent on the wall of the connection, the first and second pair of conical sealing surfaces are preferably provided at an angle of approximately four to fourteen degrees with respect to the axis of the joint while the taper angle of the first and second pair of threads is preferably approximately two to eight degrees with respect to the axis of the joint.

The hooked threads provided in the tubular connection 110 inhibit the tendency for thread jump-out. The negative angle load flank threads, when subjected to tension between the pin 112 and the box 111, develop a hoop compression component. The hoop compression locks the pin and box together thereby reducing collapse of the pin and expansion of the box. A similar reaction occurs when the tubular connection is subjected to bending wherein on the tension side of the connection, the hooked threads develop a hoop compression component locking that side of the pin and box together, while the torque shoulder absorbs the load on the compression side of the bending connection.

Figure 6 illustrates a connector serving to connect the ends of the thick walled tubular members.

Two box threaded surfaces 111 and 110' serve to inter-engage with pin threaded surfaces 110 and 111 of the two tubular members. The connection between box 111' and pin 110' is the mirror image of that between box 111 and pin 110.

CLAIMS

1. A tubular connection (10, 110) of pin and box members (11, 12; 111, 112), defining an axis, characterized in that said connection comprises first and second pairs of interengaged threads (20, 21; 120, 121) on the respective members, the first pair of threads (20, 120) being axially spaced from the second pair of threads (21, 121) at least one of said pair of threads (21, 121) being provided on a taper angle with respect to the axis, the first pair of threads (21, 121) being stepped with respect to the second pair of threads (20, 120), a first pair of engaged sealing surfaces (14, 15; 114, 115) on the pin and box members (11, 12; 111, 112) disposed adjacent the end of the pin member (12, 112) a second pair of engaged sealing surfaces (18, 19; 118, 119) on the pin and box members (11, 12, 111, 112) disposed axially between the first and second pairs of threads (20, 120; 21 121) and engaged reverse angle torque shoulders, (16, 17; 116, 117), the torque shoulder (16, 116) on the pin member (12, 112) disposed on the end of the pin member, the torque shoulder (17, 117) on the box member (11, 111) disposed on the interior end of the box member, and wherein said threads (40, 140) are hooked threads having negative angle load flanks (41, 141).

2. The connection of claim 1, characterized in that the second pair of threads (20) are cylindrical threads.

3. The connection of claim 1, characterized in that both the first and second pairs of thread (120, 121) are provided on first and second taper angles with respect to the axis of the connection (120).

4. The connection of claim 1, 2 or 3, characterized in that said hooked threads (40, 140) develop hoop compression when the connection (10, 110) is subjected to tension thereby locking the pin and box (11, 12; 111, 112) together reducing the tendency for col-

lapse of the pin and expansion of the box.

5. The connection of claim 1, 2 or 3, characterized in that when said connection (10, 110) is subjected to bending, the hooked threads (40, 140) develop hoop compression on the side of the connection in tension as a result of the bending while the engaged reverse angle torque shoulders (16, 17; 116, 117) absorb the bending load on the other side of the connection (10, 110) put in compression as a result of the bending.

6. The connection of claim 1, 2 or 3, characterized in that the engaged reverse angle torque shoulders (16, 17; 116, 117) are adapted to create a recess free bore to enhance fluid flow through the pipe, to serve as a positive stop and locking device for assembly torque, to inhibit excessive hoop compressive forces from collapsing the end of the pin (12, 112), to fix the axial relation of the end of the pin (12, 112) to the box, (11, 111) and to create axial compression over the internal surface to reduce the susceptibility of the joint (10, 110) to stress corrosion cracking in a severe service environment and to cause the first pair of engaged conical sealing surfaces (14, 15; 114, 115) to expand radially.

7. The connection of claim 1, 2 or 3, characterized in that the first and second pairs of sealing surfaces (14, 15, 18, 19; 114, 115, 118, 119) are frusto-conical surfaces provided from a range of angles of approximately four to fourteen degrees with respect to the axis of the connection (10, 110).

8. The connection of claim 1 or 2, characterized in that the sealing surfaces (18, 19; 118, 119) between the first and second pair of threads (20, 21; 120, 121) are conical surfaces provided at a steeper angle than the taper angle of said one pair of threads (21, 121).

9. The connection of claim 1 or 2, characterized in that the taper angle of said one pair of threads (21, 121) are provided on a taper angle of a range of approximately two to eight degrees with respect to the axis of the connection (10, 110).

10. The connection of claim 1 or 3, characterized in that said first and second taper angles are substantially identical.

11. The connection of claim 1 or 3, characterized in that the first and second pairs of sealing surfaces (14, 15, 18, 19; 114, 115, 118, 119) are frusto-conical surfaces provided at steeper angles than the taper angle.

12. The connection of claim 1 or 3, characterized in that the taper angle of the first and second threads (120, 121) are provided on a taper angle of a range of approximately two to eight degrees with respect to the axis of the connection (110).

13. A pin member (12, 112) for a tubular member and adapted for coaxial connection to a box member (11, 111), characterized in that the pin member (12, 112) comprises first and second axially spaced threads (20, 21; 120, 121) at least one of the threads (21, 121) being provided at a taper angle with respect to the axis of the pin, the first thread (20, 120) being radially stepped with respect to the second thread (21, 121), a first sealing surface (15, 115) on the pin member (12, 112) disposed adjacent the end of the pin member (12, 112) a second sealing surface (19, 119) on the pin member (12, 112) disposed axially between the first and second threads (20, 21; 120 121), a ~~reverse angle torque shoulder (16, 116) disposed on the~~ end of the pin member (12, 112), and wherein the first and second threads are hooked threads (40, 140) having negative angle load flanks (41, 141).

14. The pin member of claim 13, characterized

in that the second threads (20) are cylindrical threads and the first and second sealing surfaces (15, 19; 115, 119) each comprise frusto-conical sealing surfaces.

15. The pin member of claim 13 or 14, characterized in that the second sealing surface (19, 119) is a frusto-conical surface provided at a steeper angle than the taper angle of the first threads (21, 121).

16. The pin member of claim 13 or 14, characterized in that the first threads (21, 121) are provided on a taper angle from a range of angles of approximately two to eight degrees with respect to the axis of the pin (12, 112).

17. The pin member of claim 13 or 14, characterized in that the first and second frusto-conical sealing surfaces (15, 19; 115, 119) are provided from a range of angles of approximately four to fourteen degrees with respect to the axis of the pin (12, 112).

18. The pin member of claim 13, characterized in that the first and second axially spaced threads (120, 121) are provided on first and second taper angles with respect to the axis of the pin (112).

19. The pin member of claim 13 or 18, characterized in that the first and second taper angles are substantially identical and the first and second sealing surfaces (115, 119) are frusto-conical surfaces provided at steeper angles than the taper angle.

20. The pin member of claim 19, characterized in that the first and second frusto-conical sealing surfaces (115, 119) are provided from a range of angles of approximately four to fourteen degrees with respect to the axis of the pin (112).

21. The pin member of claim 19, characterized in that the first and second threads (120, 121) are provided on a taper angle from a range of angles of approximately two to eight degrees with respect to the axis of the pin (112).

22. A box member (11, 111) adapted for coaxial connection to a pin member (12, 112) disposed on the end of a tubular member, characterized in that the box member (11, 111) comprises first and second axially spaced threads (20, 21; 120, 121) at least one of the threads (21, 121) being provided on a taper angle with respect to the axis of the box (11, 111) the first threads (21, 121) being radially stepped with respect to the second threads (20, 120), a first sealing surface (14, 114) disposed adjacent the interior end of the box member (11, 111), a second sealing surface (18, 118) about the interior of the box member (11, 111) disposed axially between the first and second threads (20, 21, 120, 121), a reverse angle torque shoulder (17, 117) disposed on the interior end of the box member (11, 111), and wherein the first and second threads are hooked threads (40, 140) having negative angle load flanks (41, 141).

23. The box member of claim 22, characterized in that the second threads (20) are cylindrical threads and the first and second sealing surfaces (14, 18) each comprise frusto-conical sealing surfaces.

24. The box member of claim 22 or 23, characterized in that the second sealing surface (18, 118) is a frusto-conical surface provided at a steeper angle than the taper angle of the first threads (21, 121).

25. The box member of claim 22 or 23, characterized in that the first and second sealing surfaces (14, 18; 114, 118) are frusto-conical surfaces provided from a range of angles of approximately four to fourteen degrees with respect to the axis of the box (11, 111).

26. The box member of claim 22, characterized in that the first threads (21, 121) are provided on a taper angle from a range of angles of approximately

two to eight degrees with respect to the axis of the box (11, 111).

27. The box member of claim 22, characterized in that the first and second axially spaced threads (120, 121) are provided on first and second taper angles with respect to the axis of the box (111).

28. The box member of claim 22 or 27, characterized in that the first and second sealing surfaces (114, 118) are frusto-conical surfaces provided at steeper angles than the taper angle.

29. The box member of claim 22 or 27, characterized in that the first and second sealing surfaces (114, 118) are frusto-conical surfaces provided from a range of angles of approximately four to fourteen degrees with respect to the axis of the box (111).

30. The box member of claim 22 or 27, characterized in that the first and second threads (120, 121) are provided on a taper angle from a range of angles of approximately two to eight degrees with respect to the axis of the box (111).

FIG. 1

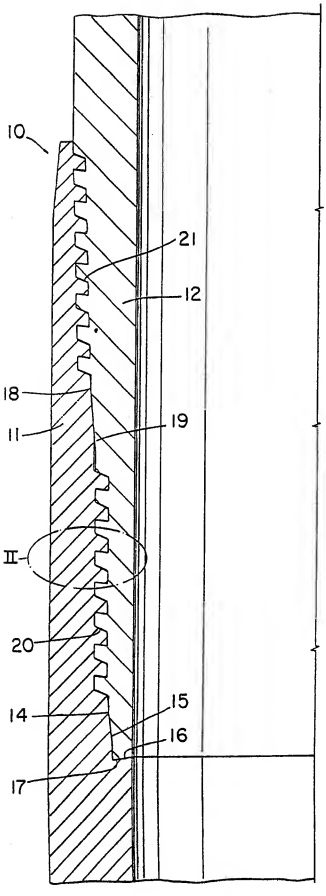
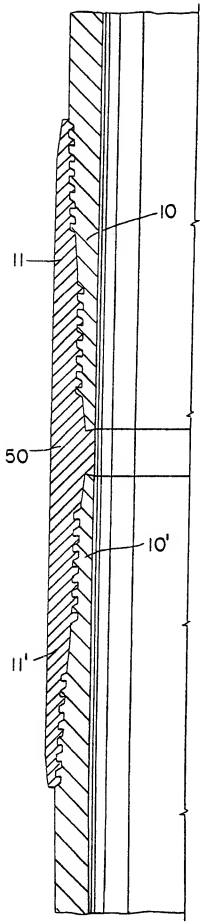


FIG. 3



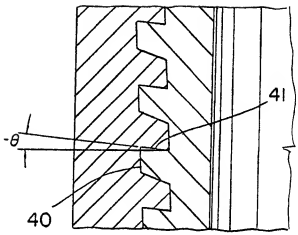


FIG. 2

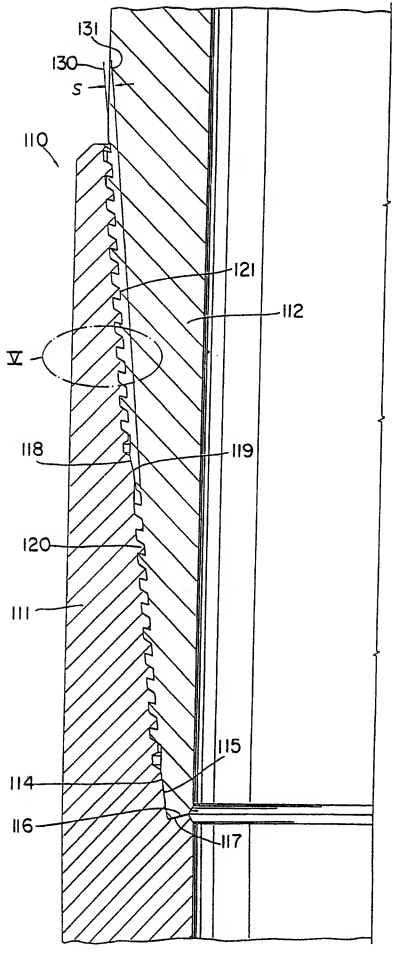


FIG. 4

FIG. 6

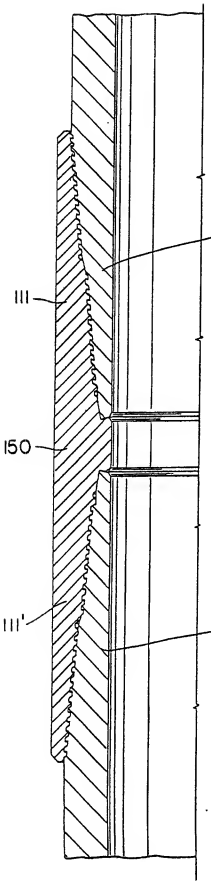
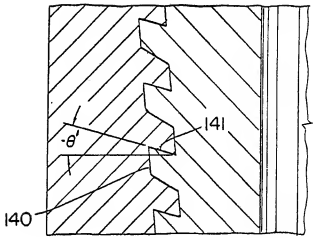


FIG. 5



INTERNATIONAL SEARCH REPORT

International Application No PCT/US 84/00520

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: E 21 B 17/042; F 16 L 15/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]	
Classification System	Classification Symbols
IPC[3]	E 21 B; F 16 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 4192533 (T.L. BLOSE) 11 March 1980 see column 2, line 25 - column 3, line 39; figures 1-8 --	1,2,4,5,13, 22
A	US, A, 4373754 (C.A. BOLLFRASS et al.) 15 February 1983 see column 5, line 9 - column 6, line 14; figure 3 --	1,2,4,5,13, 22
A	US, A, 3989284 (T.L. BLOSE) 2 November 1976 see column 4, lines 28-36 and 57-68; column 5, lines 1-11; figures 6,6a --	1,7,13,17,20 22,29
A	US, A, 4244607 (T.L. BLOSE) 13 January 1981 --	
A	US, A, 4253687 (J.H. MAPLES) 3 March 1981 --	
A	US, A, 4009893 (P. SCHATTON et al.) 1 March 1977 --	
A	US, A, 2211179 (A.L. STONE) 13 August 1940 --	
A	US, A, 3224799 (T.L. BLOSE et al.) 21	./.

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
13th July 1984	07.08.84
International Searching Authority [1]	Signature of Authorized Officer [20]
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

Form PCT/ISA/210 (second sheet) (October 1981)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
	December 1965 ------	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/US 84/00520 (SA 7001)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 02/08/84

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 4192533	11/03/80	FR-A,B	2349095	18/11/77
		DE-A-	2717795	03/11/77
		US-A-	4161332	17/07/79
		JP-A-	52148828	10/12/77
		CA-A-	1059551	31/07/79
		CA-A-	1078428	27/05/80
		GB-A-	1583038	21/01/81
US-A- 4373754	15/02/83	None		
US-A- 3989284	02/11/76	FR-A,B	2308854	19/11/76
		DE-A,C	2617667	18/11/76
		GB-A-	1495109	14/12/77
		CA-A-	1042943	21/11/78
		BE-A-	870721	15/01/79
		JP-A-	52001528	07/01/77
		US-E-	30647	16/06/81
US-A- 4244607	13/01/81	None		
US-A- 4253687	03/03/81	None		
US-A- 4009893	01/03/77	FR-A,B	2286332	23/04/76
		DE-A-	2446783	08/04/76
		GB-A-	1523484	31/08/78
		CA-A-	1040682	17/10/78
		JP-A-	51060012	25/05/76
		DE-A-	2457541	16/06/76
US-A- 2211179		None		
US-A- 3224799		None		